This invention relates to a broad band unidirectional antenna and more particularly to such an antenna suitable for use in the ultra high frequency band.

It is an object of this invention to provide an improved ultra high frequency antenna having a unidirectional response and a broad frequency band characteristic.

It is another object of this invention to provide a compact, mechanically stable antenna and reflector structure for use in the ultra high frequency band with a good gain over a large portion of the band.

Briefly, in accordance with this invention, a full wave dipole antenna with a broad band frequency characteristic, in the form of a folded sheet of conductive material having diverging sides, is located within a corner reflector and is designed to provide a proper impedance match throughout the band. Each surface of the folded sheet element is substantially parallel to the adjacent surface of the corner reflector.

The corner reflector has heretofore been suggested for use as a narrow frequency band device. The present invention makes use of the unidirectional response properties of the corner reflector, in combination with a broad band center-fed full-wave dipole antenna element. By designing the broad band antenna element to have its surfaces nearest the reflector generally parallel to the adjacent reflector surfaces, we have overcome the wide variations in impedance which would have precluded the incorporation of broad band elements in the corner reflector.

Other objects and advantages will be apparent from reading the following description in connection with the accompanying drawings, in which:

Fig. 1 is a perspective view of the antenna structure of this invention;

Fig. 2 is a side elevation of the antenna and reflector similar to that shown in Fig. 1, but having a different supporting arrangement for the dipole elements.

Fig. 3 is a front view of the antenna shown in Fig. 1, having a dipole element.

Fig. 4 shows the gain of the antenna of Figs. 1–3 over a portion of the ultra high frequency band.

Fig. 5 shows the standing wave ratio over the same portion of the band.

Fig. 6 shows the azimuthal field pattern of this antenna in relative voltage at the lower end of the present ultra high frequency television band.

Fig. 7 shows the azimuthal field pattern of this antenna near the middle of the present ultra high frequency television band; and

Fig. 8 is the azimuthal field pattern of this antenna at the upper end of the present ultra high frequency television band.

Referring now to Fig. 1, which is a perspective view of the broad band antenna and corner reflector structure of this invention, there is shown a broad band element with two arms 11, 13. Each of the two arms 11, 13 is a folded sheet of conductive material and approximates a biconical element. A corner reflector structure 15 acts as a passive current sheet reflector. Although the reflector 15 is shown as a grid of conductors, it should be understood that a solid sheet reflector, or one composed of a network of wires, such as a screen, may be used.

The dipole arms 11, 13, are folded along their lengthwise axis to have the same angle as the corner reflector 15 and positioned so that the surfaces of the broad band dipole elements 11, 13 are substantially parallel to the respective nearest surfaces of the reflector 15. The feed terminals 16 of the antenna are located at or near the adjacent apices of the dipole arms 11, 13. The dipole arms 11, 13 may be supported at their center by being secured to a block of insulating material 17, which may be supported by a metal rod, bar or tube 19 secured to the corner reflector grid structure 15. An alternative arrangement for supporting the arms 11, 13 is shown and described in connection with Fig. 2 below.

In Fig. 2, which is a side elevation of the antenna and reflector of this invention like that of Fig. 1 except for the arrangement for supporting the dipole arms, it can be seen clearly that the broad band dipole arms 11, 13 have their surfaces respectively substantially parallel to the nearest surface of the reflector 15.

Bending the triangular sheet dipole arms 11, 13 has two results which enable the corner reflector to be utilized for broad band applications. The capacity between the antenna elements 11, 13 and the corner reflector structure 15 is appreciably reduced. This smooths out the impedance characteristic of the antenna structure and reduces the loading, especially at the upper end of the band. Further, when this type of antenna is used for receiving, the currents induced by the directly received front wave and that reflected from the corner reflector surfaces 15 are maintained in a constant phase relationship due to the substantially parallel spacing of the triangular sheet antenna elements 11, 13 and the corresponding surfaces of the corner reflector structure 15.

The supporting arrangement for the dipole arms 11, 13 which are mounted on a block of insulating material 17 is a shaft 21 secured to the apex of the corner reflector structure 15 at a point designated by the reference character 23. If it is desired to convert the balanced signal of the full wave dipole antenna to an unbalanced transmission line, such as a coaxial cable 25, a balun or improper matching section 27 may be incorporated in the length of the supporting arm or shaft 21. Such an arrangement is especially desirable if an impedance transformation is to be made at the same time. Arrangements are known for converting a balanced signal to an unbalanced signal and simultaneously making an impedance transformation in the ratio of 4:1. Such a device, which can be used in box 27 of this invention to convert the 300-ohm impedance of the antenna and reflector structure to a 75-ohm coaxial transmission line, is described in U. S. Letters Patent to Lindsey, No. 2,204,965, granted July 22, 1941.

In Fig. 3, which is a front view of the antenna and corner reflector structure shown in Fig. 1, it can be seen that the dipole arms 11, 13 are positioned on the bisector of the angle between the surfaces of the corner reflector 15 and is centered laterally with respect to the reflector structure 15.

The dimensions of the entire antenna structure are shown on Figs. 1, 2 and 3 and will be described with respect to all three figures. The width across both dipole arms 11, 13 is essentially a full-wave near mid-band frequency, but for broad band application the folded-fan dipole will act as a full-wave antenna element over a range extending from 76 to 52%. The minimum width across the reflector structure 15 must be somewhat greater than that across both dipole arms 11, 13. A satisfactory value for this width has been found to be from 76 to 52%. A minimum length for each of the sides of the reflector
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structure 15 should be from ¾ to ½. The spacing “S” of the dipole arms from the apex 23 of the reflector structure 15 affects the characteristic impedance of the antenna assembly constituting the dipole and the corner reflector structure. For matching to a 50-ohm balanced transmission line over the wide band of frequencies desired, a value of 0.55 X was found to give the proper impedance. When using a full wave dipole in the corner reflector, the spacing “S” may vary between 0.2 and 0.9 X.

In the arrangement shown in Figs. 1, 2, and 3, the conductive sheets of the reflector structure 15 intersect at an angle of 90°. It is to be understood that the angle between the sheets of the reflector structure 15 may be diminished, giving increased directivity and gain. If the angle between the sheets of the reflector structure 15 is diminished, the air between the halves of the folded sheet dipole arms 11, 13 must be correspondingly reduced and it is kept so that the respective surfaces of the latter are substantially parallel to the corresponding reflector surfaces 15.

As the angle of the intersecting reflecting surfaces 15 is diminished, the spacing “S” of the dipole arms 11, 13 from the apex 23 of the corner reflector structure 15 must be increased to obtain the same characteristic impedance of the antenna and reflector structure.

In an embodiment of this antenna and corner reflector structure successfully tried out in practice which was designed for the frequency band from 500 to 900 megacycles per second, the antenna structure had the following dimensions: The width across both dipole arms 11, 13 was 14.5 inches, and the individual arms 11, 13 had a flare angle of 40° before being bent along their lengthwise axis to an angle of 90°. The width of the 90° corner reflector structure was 22.25 inches and the length along each side was 18 inches. The individual grid wires of the reflector structure 15 were composed of 0.3 inch diameter metal rods spaced 2 inches apart and carried by a metallic supporting member which was electrically and mechanically joined to the individual grid rods of the reflector structure 15 at the centers of the individual rods. The spacing of the dipole elements 11, 13 from the apex 23 of the corner reflector structure 15 was 9.25 inches for a characteristic impedance of 300 ohms.

Fig. 4 shows the gain in decibels of the antenna of Figs. 1, 2, and 3 over a portion of the ultra high frequency band relative to a tuned half-wave dipole. The reference half-wave tuned dipole is considered as matched at various points throughout the band and having a gain of zero decibels. It will be noted that the antenna structure of this invention has a gain of more than 6 decibels throughout the band for which it was designed, with the highest portion near the center of the band.

Fig. 5 shows the standing wave ratio on a coaxial transmission line connected through a 4:1 balun to the antenna over the same portion of the ultra high frequency band. It will be observed that the standing wave ratio rises only slightly above 2:1.

Figs. 6, 7, and 8 graphically illustrate the azimuthal field patterns, plotted in relative voltage, of the antenna of Figs. 1, 2, and 3 at the lower end, the middle, and the upper end of the band of frequencies for which it is designed. An inspection of these three field patterns shows that a substantially unidirectional characteristic is obtained throughout the entire band of frequencies with a relatively simple structure.

Although the broad-band dipole elements 11, 13 are shown in the figures of the drawing as being solid sheet material, these dipole elements 11, 13 may have apertures therein or be constructed of conductors spaced apart, with the ends of such conductors electrically connected to form a current sheet radiator, and the term "antenna elements of conductive sheet material," "biconical sheets," and similar descriptions in the appended claims is deemed to include this perforate or grid-like sheet.

I claim:
1. A broad band antenna structure comprising a corner reflector and a broad band dipole antenna of biconical sheets folded along the lengthwise axis of said sheets, the adjacent reflector surfaces being respectively substantially parallel to the adjacent folded sheet dipole elements.
2. A broad band antenna structure comprising a corner reflector and dipole antenna elements of conductive sheet material having diverging sides and corresponding apexes adjacent to each other, said sheets being folded along the lengthwise axis thereof, the dimension across both sheets being of the order of ¾ X to ½ X at the operating frequency, the reflector surfaces being respectively substantially parallel to the adjacent folded sheet antenna elements.
3. A broad band antenna structure comprising a corner reflector and dipole antenna elements of conductive sheet material having diverging sides and corresponding apexes adjacent to each other, said sheets being folded along the lengthwise axis thereof, the dimension across both sheets being of the order of ¾ X to ½ X at the operating frequency, the reflector surfaces being respectively substantially parallel to the adjacent folded sheet antenna elements.
4. A broad band antenna structure comprising a right angle corner reflector and dipole antenna elements of conductive sheet material having diverging sides and corresponding apexes adjacent to each other, said sheets being folded along the lengthwise axis thereof, the dimension across both sheets being of the order of ¾ X to ½ X at the operating frequency, the reflector surfaces being respectively substantially parallel to the adjacent folded sheet antenna elements.
5. A broad band antenna structure comprising a corner reflector and dipole antenna elements of conductive sheet material having diverging sides and corresponding apexes adjacent to each other, said sheets being folded along the lengthwise axis thereof, the dimension across both sheets being of the order of ¾ X to ½ X at the operating frequency, the reflector surfaces being respectively substantially parallel to the adjacent folded sheet antenna elements.
6. A broad band antenna structure comprising a right angle corner reflector having a width equal to at least ½ X at the lowest operating frequency and a length along each of the sides equal to at least ¾ X at the lowest operating frequency, and dipole antenna elements of triangular sheet material with corresponding apexes adjacent to each other, said sheets being folded to a right angle along the lengthwise axis thereof, the dimension across both sheets being of the order of ¾ X to ½ X at the operating frequency, the reflector surfaces being respectively substantially parallel to the adjacent folded sheet antenna elements.
7. A broad band antenna structure comprising a right angle corner reflector having a width equal to at least ¾ X at the lowest operating frequency and a length along each of the sides equal to at least ¾ X at the lowest operating frequency, and dipole antenna elements of triangular sheet material with corresponding apexes adjacent to each other, said sheets being folded to a right angle along the lengthwise axis thereof, the axis of said sheets being located on the bisecting plane between the surfaces of said corner reflector and spaced from the intersection of said reflector surfaces by 0.2 to 0.9 of the wave length at mid-band frequency, the dimension across both sheets being of the order of ¾ X to ½ X at the operating frequency, the reflector surfaces being respectively substantially parallel to the adjacent folded sheet antenna elements.
8. A broad band antenna structure comprising a right angle corner reflector having a width equal to at least \( \frac{3}{4} \lambda \) at the lowest operating frequency and a length along each of the sides equal to at least \( \frac{3}{4} \lambda \) at the lowest operating frequency, dipole antenna elements of triangular sheet material with corresponding apexes adjacent to each other, said sheets being folded to a right angle along the lengthwise axis thereof, the axis of said sheets being located on the bisecting plane between the surfaces of said corner reflector and spaced from the intersection of said reflector surfaces by 0.5 \( \lambda \) to 0.6 \( \lambda \) at the mid-band frequency, the dimension across both sheets being of the order of \( \frac{3}{4} \lambda \) to \( \frac{5}{4} \lambda \) at the operating frequency, the reflector surfaces being respectively substantially parallel to the adjacent folded sheet antenna elements, support means for said antenna elements mechanically secured to the intersection of said corner reflector surfaces and carrying said antenna elements on the free end thereof, and an impedance matching section included in the length of said support means and electrically coupled to said dipole antenna elements.

9. A broad band antenna structure comprising a right angle corner reflector having a width equal to at least \( \frac{3}{4} \lambda \) at the lowest operating frequency and a length along each of the sides equal to at least \( \frac{3}{4} \lambda \) at the lowest operating frequency, dipole antenna elements of triangular sheet material with corresponding apexes adjacent to each other, said sheets being folded to a right angle along the lengthwise axis thereof, the axis of said sheets being located on the bisecting plane between the surfaces of said corner reflector and spaced from the intersection of said reflector surfaces by 0.5 \( \lambda \) to 0.6 \( \lambda \) at the mid-band frequency, the dimension across both sheets being of the order of \( \frac{3}{4} \lambda \) to \( \frac{5}{4} \lambda \) at the operating frequency, the reflector surfaces being respectively substantially parallel to the adjacent folded sheet antenna elements, support means for said antenna elements mechanically secured to the intersection of said corner reflector surfaces and carrying said antenna elements on the free end thereof, an impedance matching section included in the length of said support means, feed terminals near the adjacent apexes of said antenna elements, a balanced transmission line connected to said feed terminals and said impedance matching section, and an unbalanced transmission line connected to the other end of said impedance matching section.

10. A broad band antenna structure comprising a corner reflector whose reflector surfaces form an angle not greater than substantially 90° and a sheet antenna folded along an axis parallel to the intersection of the surfaces of said corner reflector, the reflector surfaces being respectively substantially parallel to the adjacent surfaces of said sheet antenna, said antenna being positioned within said angle.

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